South America's Longest Suspension Bridge Will Be Earthquake Resistant

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This monthly column features "Our Stories" from worldsteel, covering automotive, construction and building, infrastructure, and innovation.

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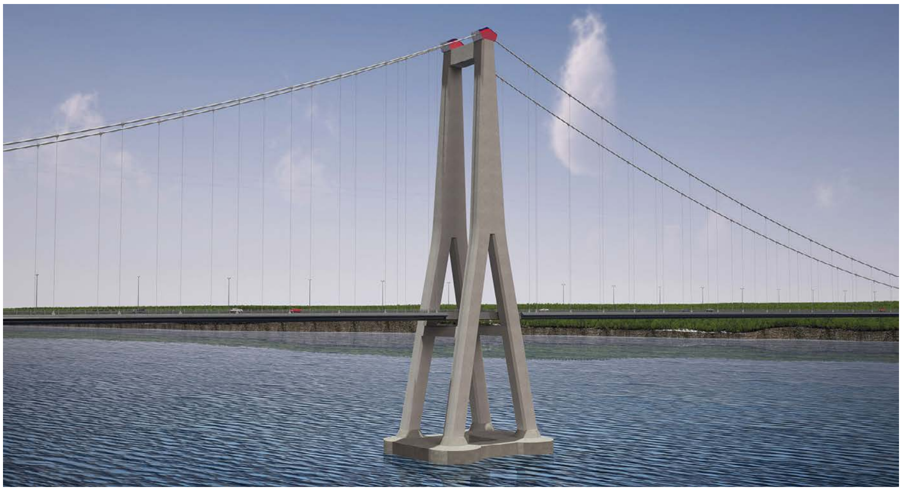

In one of the most challenging engineering projects ever undertaken, Chile is building a unique steel-built suspension bridge near the site of the strongest earthquake ever recorded.

Planned to open in 2023, the Chacao suspension bridge is sited just 80 km from a seismic fault zone where a record-shattering 9.5 magnitude earthquake struck in 1960 and an offshore earthquake measuring 8.8 hit the area in 2010.

This isn't the only challenge that faces the designers, as the bridge will link the island of Chiloe to the mainland across a sea channel that comes with powerful currents and winds that can reach speeds of more than 200 kph.

Set to cost more than US$700 million, once completed the bridge will replace the ferry service that runs to Chiloe, bringing travel times down from 30–45 minutes to just 3 minutes. This will massively impact the island's economy and, it is hoped, will boost tourism in the area.

Rising to the Challenge

Spanning 2,750 m, the Chacao will be South America's longest suspension bridge. Tackling a project of this scale required a robust design, engineering and construction team. A consortium made up of OAS, Hyundai, Systra and Aas Jakobsen won the work from the Chilean government, with Hyundai leading on construction and bringing in Arup as a consultant.

Arup formed a multi-disciplinary consultation team to deal with the challenging site conditions, with geotechnics, maritime impacts, wind and seismic engineering, and anchorage and foundation design all key parts of the planning process.

Galvanized steel wire also offered the best breaking-strength-to-weight ratio for the suspension bridge cables, allowing the designers to fully optimize the bridge's support structures while meeting the unique site requirements.

The 2.7-km span of the bridge will be supported by three steel-reinforced concrete towers, with two main spans measuring 1,055 m and 1,100 m, and a suspended side span of 380 m. Supporting a highway with two lanes running in each direction, the 175-m-tall central tower will sit on Roca Remolinos, a small reef in the middle of the channel where a rocky outcrop breaks the surface.

Due to the high seismic activity in the area, it was vital that the structure of the suspension bridge have a correspondingly high ductility to deal with potential tremors. To ensure the seismic performance of the concrete towers, steel reinforcement bars were required in the pile structure, in addition to an external 70-mm-thick steel casing at their top. This steel core also gave the foundations the flexibility to deal with the surging tides that hammer the bridge's coastal location.

The pylons that support the bridge deck are reinforced with steel due to its seismic performance.

Surface-Level Strength

It's not just in the bridge's foundations that steel is adding unparalleled ductility and strength. Throughout its superstructure, steel is crucial to the performance of the bridge against challenging environmental criteria.

Designed for a 100-year life span, the bridge's 24-m-wide deck is fabricated from structural steel plate that allows it to resist wind speeds of more than 240 kph. At the heart of this is its orthotropic box girder design, fashioned from 20,700 metric tons of high-strength steel.

Orthotropic bridge decks are stiffened longitudinally with lattice girders and transversely with floor beams. This allows the bridge deck to carry vehicular loads while also contributing to the overall load-bearing structure.

High-strength steels allow for lighter structures that do not compromise on durability and strength. This material performance is vital as the bridge deck and main cable weight, as well as the number of pylons, had to be kept as low as possible due to seismic activity.

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To achieve a project like this, which pushes boundaries and has the power to connect communities in hard-to-reach locations, the designers are squeezing every last drop of performance from their materials. It is clear that when it comes to realizing the impossible, engineers will continue to reach for steel.

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